Implementing a Residency Scheduling Program at the University of Michigan Pediatric Emergency Department

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BRIEF BACKGROUND ON RESIDENCY

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What is medical residency?

- Transition period between medical school and fully independent/unsupervised practice
  - Four years of med school
  - First year of residency – “Intern”
  - Two more years of residency
  - Possibly one or two additional years as “Chief Resident”
  - Possibly more years as a “Fellow”
- During all of this time, providing patient care (albeit with the oversight of a more senior “attending” physician –supervision decreases over time)

What is medical residency?

- A key issue: Dual role of residency
  - Learning experience: Residency (and Fellowship) are parts of the medical education training process
  - Patient care: Residents/Fellows provide a significant amount of the patient care in teaching hospitals and the associated clinical system
- A typical resident might engage in all of the following activities:
  - “Continuity clinics”
  - Shifts on service
  - Seminars, formal educational activities
  - Research

Inherent Time Conflicts

- How to schedule residents' time
  - Need adequate patient coverage with a limited pool of residents
  - Need adequate training opportunities
  - Need adequate rest – fatigue increases risk of error
  - Need to address resident satisfaction, personal life
- Not just quantity of hours but pattern
  - Continuity of care
  - Sleep issues (especially associated with overnight shifts)
  - Opportunities for different medical experiences
  - Quality of life, fatigue, and stress issues

MONTHLY SHIFT SCHEDULING OF PEDIATRIC EMERGENCY DEPARTMENT RESIDENTS

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What is the general problem?

- **Given a set of residents assigned to a shift-based service, build a month-long schedule that satisfies all patient care, educational, and other requirements**

What is our specific problem?

- **Assigning residents to shifts to cover the pediatric emergency department in Mott Children's Hospital at UMHS**
- **Eight overlapping shifts per day**
- **Month-long schedule (but conflicting *switch dates* depending on the resident)**
- **Approximately 15 residents per month, coming from four or five different residency programs**

What are the rules?

- Patient care requirements:
  - 8 overlapping shifts every day of the month
  - Every shift has to have exactly one resident assigned
  - Exceptions: 10a – 7p and 12p – 9p shift coverage is optional
    - Not *all* of these shifts can be left uncovered for the entire month
    - Ideally one of the two "flex shifts" should be covered each day
  - Certain shifts cannot be assigned to an intern
  - Certain overlapping pairs of shifts require a Peds resident on at least one of the two shifts
  - …

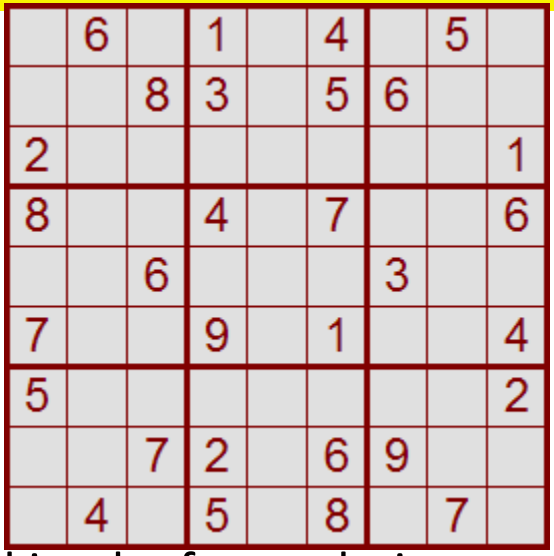
What are the rules?

- Resident availability
  - Senior residents switch on the first of the month
  - Interns switch on the 27th of the preceding month
  - Pre-assigned vacation time must be respected
  - Continuity clinics/post CC
  - Some shifts are pre-assigned to certain residents/programs
  - 10-hour rule
  - First and last shifts must recognize boundaries of other rotations
  - …

What was the current state?

- Schedules typically built by Chief Residents
- Limited decision support
- No formal training
- Hard to satisfy all rules
- Unlikely to make everyone happy

Why is it hard to schedule manually?



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2								1
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		6				3		
7			9		1			4
5								2
		7	2		6	9		
	4		5		8		7	

- The more squares you fill in, the fewer choices you have left for what is valid
- Once you make a mistake, you might not know it for a long time
- Once you realize something is wrong, it can be very hard to back track and correct
- If a requirement changes, you have to start from scratch

How do we solve it?

- Mixed integer programming approach
  - x_{rsd} = 1 if resident *r* is assigned to shift *s* on day *d*, else 0
- Feasibility constraints are straightforward to model
- Run time using C++ and CPLEX on a standard PC is minimal (a few seconds at most)
- Finding a schedule that satisfies the rules is already progress over what exists (especially given time required)
- But not all feasible schedules are equally good

How to “optimize”?

- No one clear objective function, but many important metrics
  - Equity across residents
    - Number of shifts
    - Number of night shifts
    - General quality of schedule
  - “Bad sleep patterns”
  - Personal requests
  - Post-continuity clinic calls
  - Flex shift coverage
  - Transition shift coverage

How to “optimize”?

- We could treat this as a multi-criteria objective function, assign weights to normalize, and solve
  - Weights are hard to find
  - Convergence can slow dramatically
- Is “optimal” the right goal???
  - Is this an engineering construct that we’re imposing inappropriately?

How to “optimize”?

- Our approach:
  - Set boundaries on the metrics
  - Define as hard constraints
  - Search for a feasible solution
    - If found, review and decide what to tighten next
    - If not found, loosen the boundaries
  - Repeat until satisfied

Current Work: Pareto Optimization

- No established rank order of metrics
- No weights can easily be established
  - "Game" for testing Chiefs' ability to provide appropriate weights
  - Preferences change from one month to another, e.g. when launching EMR
- Attempting to generate Pareto-dominant set of solutions
  - Given a solution, can add appropriate cut and re-solve to find a Pareto-improvements
  - Need to then "jump" to new solutions

ANNUAL BLOCK SCHEDULING OF PEDIATRIC RESIDENTS

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Motivation

- Some months are easy to solve the ED shift scheduling problem, others very hard – why?
- Often depends on number of interns for the month (affect start/end periods and ability to fill shifts) and/or overlaps in continuity clinics
- Why do some months have lots of interns, others few? Why might cc's overlap (or not)?

Block Scheduling Problem

- Over the course of the year, residents must work on many *services*, divided in monthly *blocks*
  - Emergency medicine
  - Hematology/Oncology
  - NICU
  - Etc.
- Residents span multiple levels of seniority and come from multiple programs

Block Scheduling
Requirements and Challenges

- Requirements
  - Coverage constraints (patient care)
  - Educational constraints
- Challenges
  - Vacation requests
  - Repeating hard services
  - Split-months (e.g. ½ ED, ½ vacation)

Approach

- Again, can formulate a straightforward IP
  - "Service pairs" as templates to recognize possible half-month combinations
  - Xrpm=1 if resident r is assigned to service pair p during month m
- Constraints are fairly straightforward

Approach

- Challenge is again with the objective function
  - Trading off vacation time requests vs “triple-H” limitations
  - Trading off vacations across residents, interpreting importance of requests
  - Lots of input from Chief (acceptable), lots of tweaking of the code (not so acceptable)

ISSUES OF GENERALIZATION

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Higher Level Goals

- Shift scheduling occurs in many other contexts
- Block scheduling occurs in many other contexts
- Can we generalize models, computational frameworks, file i/o, etc. in such a way to generalize, encompass multiple environments with a single tool
  - Best to group by specialty, by time frame, or overall?

QUESTIONS, COMMENTS AND DISCUSSION

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